A Journey into Entomology

Volume- 1

(A peer-reviewed book)

Chief Editor & Published by

Anand Kumar Thakur, Ph.D.

Assistant Professor, University Department of Zoology (Entomology), Ranchi University, Ranchi, Jharkhand
Email ID: fmruanand@gmail.com

Publication design & Graphics by:

Lekh Publications

A publication unit run and governed by Ashalok Trust, Ranchi.

(Reg. No. 2023/RAN/2293/BK4/202)

Head Office: 1A, Sita-Prabhawati Apartment, Jora Talab Road, Bariatu, Ranchi - 834009

Email: ajourneyintoentomology@gmail.com

Branch Office: D/5, Ajanta Niketan, Rajiv Nagar, Patna - 800024

Printed by:

I. D. Publishing, Kokar, Ranchi - 834001

Page Design by: Ravi Rahul Singh

Publication Year (month): 2023 (May)

Pages: 96

ISBN: **978-93-5811-323-5**

Price: ₹ 400.00, USD: $10.00

Indexed by: OpenAIRE | EXPLORE

Disclaimer:

This book represents the personal views and opinions of the author and does not necessarily reflect the positions or opinions of any organization, institution, or individual with which the author is affiliated. The content presented herein is based on the author's perspective and interpretation of the subject matter. Neither the publisher nor any associated parties shall be held responsible for any consequences arising from the opinions or interpretations expressed within this book.

CHAPTERS

Major Threats on the Insect Pollinators in India

Anand Kumar Thakur*
Assistant Professor, University Department of Zoology, Ranchi University, Ranchi
Email: fmruanand@gmail.com
DOI- https://10.5281/zenodo.7965969
https://orcid.org/0000-0002-4392-142X

ABSTRACT:- Insects are the most common pollinators. Bees, wasps, butterflies, moths, and beetles are common among pollinators. All economic plants including cereals, oilseeds, fruits, vegetables, and forest trees mostly depend for their reproduction on these pollinators. Reports say the threat to them is because of habitat loss, climatic stress, invasive flora and faunal encroachment, chemical pesticides, exposure to competition, starvation, etc. The objective of writing this chapter is to introduce different types of threats to pollinators, affecting factors, challenges in the future, and their restoration. Integrated pest management (IPM) can play an important role in the protection of pollinators. It can include continuous research work, awareness programmes, and the development of pollinator pro systems. It can be climate-smart agro-horticultural management, pathogen-disease control management, the introduction of natural predators to control pests, and minimizing the application of chemical pesticides.

Keywords- Insect Pollinators, Lepidoptera, APEDA

INTRODUCTION

The diversification of insects and their adaptation to any kind of habitat makes them one of the most dominating classes on the earth[1]. Insects belonging to orders Lepidoptera, Diptera, Hymenoptera, and Coleoptera are major stakeholders among pollinators[2]. Bees, Butterflies, Moths, Beetles, and Wasps are major pollinators. Pollination is a process of the transfer of pollen grains from the anther to the stigma in phanerogam plants. This process is indispensable for the reproductive life cycle of such plants. It is considered a source of random mating process in them responsible for variations. Ollerton *et al*. (2011)[3] said that 90% of flowering plants reproduce with the help of insect pollinators only. The concept of co-evolution also advocates the behavioural and

structural relationship between flowers and their pollinators[4]. The economy of India is greatly regulated by the production of crops, fruits, and vegetables. Among them crops depend for 51.2%, oilseeds depend on 34.07% parts of their yield on insect pollinators while fruits follow with 14.82%[5]. It means the pollinator plays a critical role in the life of farmers for their better yield. Therefore, a decline in the population of pollinators can also decline the food security and income from the crops to the farmers. The Agricultural and Processed Food Products Export Development Authority (APEDA) reported that only Honeybee contributes approximately 20% of the total yield of crops in India. Approximately 1.6 US dollars can monetize it. Among insects, honeybees are studied widely to understand the role of active pollinators. Among cereals - Rice (*Oryza* spp.), Wheat (*Tritium* spp.), Maize (*Zea* spp.) and Bajra (*Pennistum* spp.) are major crops pollinated by insects. Bennett *et al.* (2020)[6] reported that anthropogenic landscapes like gardens, parks and plantations with floral resources showed lower plant reproduction than natural landscapes. Some common insect pollinators in India are

Table 1: List of some common insect pollinators in India.

Sl.No.	Common Name	Scientific name	Family
1.	Honeybees	*Apis cerana* *Apis mellifera*	Apidae
2.	Hoverflies	*Eristalis* spp. *Syrphus* spp.	Syrphidae
3.	Carpenter bees	*Xylocopa* spp.	Apidae
4.	Mason bees	*Osmia* spp.	Megachilidae
5.	Leafcutter bees	*Megachile* spp.	Megachilidae
6.	Bumblebees	*Bombus* spp.	Apidae
7.	Beetles	*Mordella* spp., etc.	Scrabaeidae Curculionidae
8.	Wasps	*Vespula* spp., etc.	Vespidae
9.	Moths	*Helicoverpa* spp., etc. *Spodoptera* spp., etc.	Lepidoptera
10.	Skippers	*Tetractrocera* spp., etc.	Hesperiidae
11.	Sweet bees	*Lasioglossum* spp., etc.	Halictidae
12.	Long-horned bees	*Cerantina* spp., etc.	
13.	Digger bees or Mining bees	*Andren* spp.	Andrenidae
14.	Butterflies	*Papilio pollutes* *Pieries canidia indica* *Vanessa cardui* etc.	Papillionidae Pieridae Nymphalidae

listed below in Table 1: Bennett *et al.*, (2020)[6] reported that anthropogenic landscapes like gardens, parks and plantations with floral resources showed lower plant reproduction than natural landscapes. Some common insect pollinators in India are listed below in Table 1:

The objective of writing this chapter is to raise the threats to insect pollinators. What are the various factors behind this issue? What shall be the impact of the loss of pollinators from an area? How this problem can be solved? In addition, what steps do we have to take to protect the ecosystem practices of pollinator-flower relations?

The data for this chapter are obtained by data mining from different online authentic sites. Then selected papers were carefully read and valuable information was extracted.

2. PROBLEMS FOR INSECT POLLINATORS IN INDIA

Insect pollinators are very sensitive to their habitat, food plants, climatic conditions and life-table parameters. Any kind of disturbance can produce a negative impact on them. In the following points, the issue is discussed:

2.1 HABITAT LOSS AND DEGRADATION:

Habitat is a natural environment where a plant or animal lives and thrives. It is degraded or fragmented by natural and humanized fabricated activities. To fulfill the need of increasing human population forests, grassland, wetlands, and water reservoirs is continuously fabricated into housing colonies, parks, industrial infrastructures, and others. Hadley and Betts (2012)[7] reported the negative impact on the abundance, species richness, and diversity of plants in such areas.

2.2 USE OF CHEMICAL PESTICIDES

Several scientific studies revealed the impact of the use of chemical pesticides on the loss of pollinators from an agro-horticulture area. A work published by Whitehorn *et al.*, (2014)[8] in the journal 'Science" said that widely used neonicotinoid pesticides reduced the survival and reproduction of Bumblebees. Pollinator insects are killed by the use of chemical pesticides through ectopic use or ingestion. Bees, butterflies, and moths play a crucial role in pollinating many crops and forest trees. Spraying of such insecticides contaminates floral parts of the crop and therefore both nectar and pollen grains transfer them to the pollinators. The effect of chemical insecticides (Table 3) on pollinator can be detailed as follow:

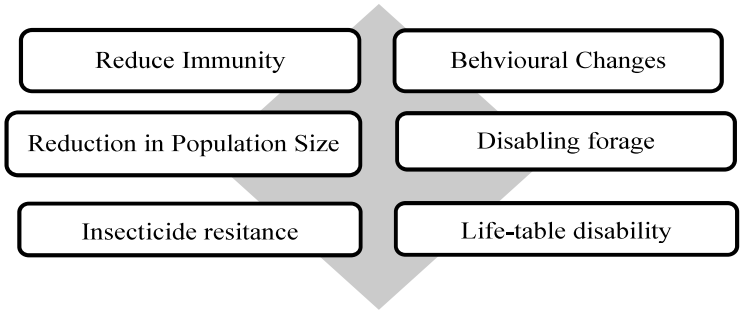
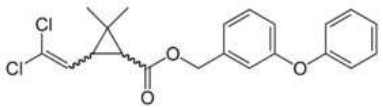


Figure 1: Effect of chemical insecticides on the pollinators.

(a) Reduction in population size by causing death or blocking the reproduction of pollinators.

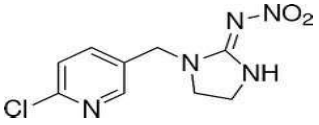
(b) Reduce immunity of pollinators and make them more sensitive to different diseases. For example, the immunity of bees is reduced by the application of neonicotinoid and become more sensitive to diseases like Nosema and Varroa mites[9,10]. The immunity in butterflies is suppressed by the application of pyrethroids[9].



Pyrethroid

(c) Behavioural changes of pollinators reduce their ability to communicate and perform vital tasks such as mating and parental care of their eggs and nymphs. Pyrethroids alter the orientation of butterflies therefore the flowers incomplete their life cycle because of the lack of pollination[11].

(d) Disabling the ability to forage and return to their colonies by impairing their nervous system. It is commonly observed in honeybees (*Apis*) and bumblebees (*Bombus*). Here, insecticides like neonicotinoids impair their memory and learning ability[9,10,12].



Neonicotinoid

Fig. 2: *Bombus*
(Source: Encyclopaedia Britannica)

(e) Effect on the egg production is severe for the life cycle of the insects. It may cause the loss of the link in a food web. It also passes these insecticides to its predators like bats and birds. For example, Bluebirds (*Sialia*), Swallow birds (*Hirundinidae*), and Woodpeckers (*Picidae*) are highly affected by the relay of insecticides from their food insects.

(f) Development of insecticide-resistance insects can be more difficult to control. Such pests can damage the cropland, massively. For example, *Helicoverpa armigera* – the Cotton bollworm is a major threat to cotton crops. It is reported that it developed resistance against multiple classes of insecticides like Pyrethroids and Neonicotinoids. Other examples are Bed bugs (*Cimex*), Mosquitoes (*Anopheles, Culex*, etc.)[13,14], Colorado potato beetles (*Leptinotarsa decemlineata*) and others.

2.3 CLIMATE CHANGE

Climate change takes place through natural activities and anthropogenic interferences. It is reported by several scientists that these changes have negative effects on the insect pollinators like moths, wasps, bees and butterflies. The most common environmental factors that affect the climate are temperature, rainfall, humidity, wind speed and photoperiod. Kumari & Thakur (2021)[15] and Thakur (2021)[16] reported that anthropogenic activities alter the climatic conditions and therefore the biodiversity of butterflies declined in Ranchi. There is a relationship between the timing of flowering and the emergence of pollinators. Drought and heat waves also harm pollinators and their habitats. These changes also damage the host plants and promote the scarcity of food for their pollinators.

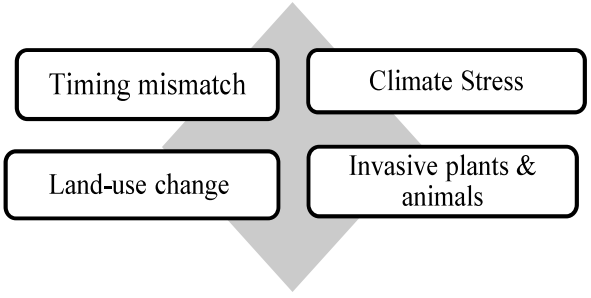


Figure 3: Effect of climate change on the pollinators.

(a) Timing mismatch is the biggest impact of climate change due to which the flowering period and the emergence of pollinators vary. It leads to the shedding of non-pollinated flowers prior to the pollinators. The warming temperature and fluctuation in rainfall patter cause the shift in the timing of flowering.

(b) Climate stress may shift the pollinators from the horticulture area to the poles. For example, Cameron *et al.*, (2011)[17] reported the shifting of bumblebees toward to pole up to 300-kilo meters away from its site in dew decades.

(c) Decrease in crop yield is reported by the reduction of pollinators in the cropland because of climate stress. Aizen *et al.*, (2016)[18] reported evidence that relates to the reduction of insect pollinators and decreased crop production.

(d) Land-use changes because of climatic stress. It shows a negative effect on insect pollinators. In this regard, a report by Kleijn *et al.*, (2015)[19] was published which provides evidence of the negative effect of alternation of land use on insect pollinators.

2.4 DISEASES

Diseases, parasites and predators are common in any ecosystem. It is a process. However, when these factors become dominant due to any reason either natural or fabricated situation they may lead to the loss of pollinators. There are many examples of such diseases listed in Table 2.

2.5 INTRODUCTION OF NON-NATIVE SPECIES

In agriculture, it is often to crop non-native species of plants for more yield and to enhance quality. In India, it is continuously observed during and after the green revolution. However, during the course of different observations and results, it was reported by several scientists have that these non-native species harm the ecosystem. Because, these non-native species compete with native pollinators for food, habitat, and reproduction, and carry new types of diseases and parasites. These things harm the native pollinators and may cause severe damage to the cropland and other associated areas. For example, the non-native European honeybee was introduced to many countries and they outcompeted native bee species and spread diseases too. Finally, it results in the decline of both the native pollinator population and the yield of the crop. 'Asian Giant Hornet' (*Vespa mandarinia*) is also called the 'Murder hornet' and

decimates entire hives of native bees. 'Red Imported Fire Ant' (*Solenopsis*) is a popular invasive species reported in India that damage insect pollinators like bees and butterflies.

Table 2: Listing of common diseases in insect pollinators in India. The list includes types of disease, causing factors, name of causing agents, target pollinator and the symptoms and affecting stages of the life-table of pollinators.

SN	Disease	Type	Agent	Target pollinator	Symptoms & affected stage of life-table of pollinators
1	Nosema	Fungal	*Nosema apis*	Bees & Honeybees	Diarrhoea, weight loss
2	Varroa mite infestation (VMI)	Insect	*Varroa destructor*	Honeybee	Bloodsucker
3	Wax moth infestation	Insect	*Galleria mellonella*	Honeybee	Beehive destroyer
4	Deformed wing virus (DEV)	Virus	*Varroa destructor virus-1*	Honeybees, Moths & Butterflies	Wrinkled wings & shortened abdomen
5	Colony collapse disorder (CCD)	Ecological factors	Pesticides, Poor nutrition, Stress etc.	Honeybees	The disappearance of adult honeybees from hives.
6	Israeli acute paralysis virus	Virus	Israeli acute paralysis virus	Honeybees	Paralyze the bee
7	Chronic bee paralysis (CBP)	Virus	CBP virus	Honeybees	Paralyze the bee
8	Foulbrood disease	Bacteria	*Melissococcus pluton*	Honeybees	Affect larvae & pupae
9	Sacbrood virus (SBV)	Virus	SBV	Honeybees	Stunted & discoloured larvae
10	Black queen cell virus (BQCV)	Virus	BQCV	Honeybees	Damage larvae & pupae
11	American foulbrood	Bacteria	*Paebibacillus*	Honeybees	Damage larvae & pupae
12	Chalkbrood disease	Fungal	*Ascosphaera apis*	Honeybee	Damage larvae & pupae

Fig.4: Red Imported Fire Ant

Fig.5: Asian Giant Hornet

2.6 LACK OF FLORAL RESOURCES

The relationship between flowers and pollinators is a good example of mutualism. Both have a kind of interdependence and have co-evolutionary relations. The lack of floral resources has a negative effect on the population dynamics of pollinators. In this case, pollinators disperse to the site in the search of food and face severe life threats. It can be detailed in the following points:

(a) The fewer flower resources in an ecosystem lead to food scarcity. It can happen by the mismanaged use of fertilizers, acidity of soil and climate alteration[20].
(b) Potential risk of starvation of the pollinators due to traveling farther in the search of food. Exposure to predators is reported during this travel.
(c) Exposure to competition
(d) Negative impact on reproductive stress
(e) Habitat loss
(f) Effect on ecosystem

3. WHAT STEPS HAVE BEEN TAKEN TO SOLVE THE PROBLEM?

The mutual interaction of pollinators and flowering plants is very important for the success of the ecosystem. Integrated pest management (IPM) is playing an important role in this direction. Some important steps are taken to minimize the decline of insect pollinators in India:

3.1 Habitat protection, restoration, and conservation of pollinators can be secured by taking steps on the following points:

(a) Establishment of pollinator parks like biodiversity parks, botanical gardens, nectar-rich shrubs, trees, and others.
(b) Promotion of organic farming through minimized use of insecticides and other harmful chemicals in the agro-horticultural areas.
(c) Restoration of natural forests, grasslands, and wetlands.

3.2 Insecticide management can be a key player in protecting pollinators. Under this process, the farmers can select selection of a suitable insecticide with the least toxic impact. Second, the timing of spry of these insecticides can also be managed in a way when the emergence of pollinators is very low. Flowers

should not be sprayed. Implementation of mandates of integrated pest management (IPM) can help a lot like promoting natural predators that can minimize pests in the cropland. In this way, pollinators can be protected.

3.3 Climate-smart agriculture and horticulture are good ways to protect pollinators and minimize pest infestation. Pollinator-friendly farming is a good agricultural management practice. It may include a good resource of food, nesting sites and minimum use of harmful insecticides.

3.4 Pathogen and disease management can include regular monitoring of the pollinator population and their health. Identification of diseases and pathogens is important for the health of pollinators. Studying the life cycle of these pathogens can ease the researcher to develop remedial treatment. Research and monitoring are critical to maintaining the population of pollinators.

3.5 Invasive species of either plants or animals should be controlled effectively to protect pollinators.

(a) For this, early detection of such species is critical and only regular monitoring can do it.

(b) The introduction of natural predators or pathogens of the target invasive species can manage them. For example, the two-spotted spider mite (*Tetranychus utricae*) is a pest of many crops and flowers and therefore, affects the health of pollinators. The introduction of predator mites (*Phytoseiulus persimilis*) can control the pest. Use of a group of bacteria to control the other pathogenic bacteria of Americal foulbrood in honeybees.

(c) The use of suitable herbicides to control invasive weeds positively affects pollinators' population. Neem oil, Pyrethrum, *Bacillus thuringensis* (Bt) and Rotenone are some common examples. Neem oil is obtained from the *Azadirachta indica* plant and affects the reproduction of pests without affecting pollinators like bees and butterflies. Pyrethrum is obtained from *Chrysanthemum* flowers. It also affects pests but is found relatively safe for pollinators. Bt is a soil bacterium and is found toxic to pests. It is biotechnologically used to protect against pests but not against pollinators.

(d) Native habitat restoration can create a chance to develop their population.

(e) Bio-insecticides are prepared to control pests. But they should be applied only when pollinators are not present in the place. Like a bio-insecticide developed from a fungus, *Beauvaria brassiana* can kill bees.

(f) Lack of scientific information and approach among the farmers and common people is very important for the preservation of pollinators. Therefore, planned way of education and awareness programs can help the common people to understand the importance of pollinators in their cropland and also become enable them to protect them. Michigan State University, USA has created some online classes to aware people to know pollinators, their benefits, threats, and measures to protect them.

4. WHAT IS THE PRESENT STATUS OF THE ISSUE?

Different reports of both government and non-government agencies clearly depict the status of the problem of the declining insect pollinator population in India. It says that the situation is complex and varies in different parts of India. In some places, the population dynamics of pollinators are very good while in other areas it is worrisome. Regions of India where insect pollinators are declining are listed below in the table:

Table 3: List of the region of India and their states with declining pollinators and the cause behind the issue.

SN	Region of India	States	Pollinator type	Cause
1	Northern India	Uttar Pradesh, Haryana and Punjab	Honeybee	Habitat loss and Insecticides
2	Western India	Maharashtra and Gujarat	Honeybee	Habitat loss and Insecticides
3	Southern India	Karnataka, Andhra Pradesh and Tamil Nadu	Honeybees, moths and butterflies	Habitat loss, Diseases and Insecticides
4	Eastern India	West Bengal, Orissa, Bihar	Honeybees, moths and butterflies	Habitat loss and Insecticides

Conservation and Integrated pest management (IPM) strategies have a positive impact on the population of insect pollinators in India[21,22]. Wildlife conservation acts and other acts based on the protection of the

biodiversity of insect pollinators are also effective to seek the attention of government and non-government agencies toward the issue.

CONCLUSION

Habitat loss and fragmentation along with profuse use of harmful chemicals in the agro-horticultural and agro-forestry areas can decline the population of insect pollinators. More studies are needed to design a framework for effective management. The deviation in pollination interactions with plants, pollinator density in an area and pollinator movement in an ecosystem are highly affected by various climatic factors. Therefore, climatic stress mainly temperature and rainfall affect them a lot. The author recommended more focus on experimental and observational studies of them. Methodologies that are more accurate are required for the accuracy of the results. It shall help researchers to develop a sustainable mechanism to save them at a low cost.

REFERENCES

1. Arya, D., Goswami, D., Bora, S., Rekha, & Kaushal, B. R. (2022). Diversity of butterfly pollinators in agroecosystems of Kumaun region. *Indian Journal of Entomology*, 1–5. https://doi.org/10.55446/ije.2021.359
2. Sathe, T. V., & Gophane, A. (2015). Pollinating insects of some economically important plants of Kolhapur region, India The area of pollinator dependant crops is increasing disproportionately and crop pollinators are under threat of pesticides and other chemicals used in agriculture farming. *Biolife*, *3*(3), 576–582. https://doi.org/10.17812/blj.331.2015
3. Ollerton, J., Winfree, R., & Tarrant, S. (2011). How many flowering plants are pollinated by animals? *Oikos*, *120*(3), 321–326. https://doi.org/10.1111/j.1600-0706.2010.18644.x
4. Futuyama, D. J. & Kirkpatrick, M. (2017). *EVOLUTION* (4 E). Sinauer Associates, Inc. Publishers. USA.
5. Chaudhary, O. P., & Chand, R. (2017). Economic benefits of animal pollination to Indian agriculture. *Indian Journal of Agricultural Sciences*, *87*(9), 1117–1138. https://doi.org/10.56093/ijas.v87i9.73903
6. Bennett, J. M., Steets, J. A., Burns, J. H., Burkle, L. A., Vamosi, J. C., Wolowski, M., Arceo-Gómez, G., Burd, M., Durka, W., Ellis,

A. G., Freitas, L., Li, J., Rodger, J. G., ªtefan, V., Xia, J., Knight, T. M., & Ashman, T. L. (2020). Land use and pollinator dependency drives global patterns of pollen limitation in the Anthropocene. *Nature Communications*, *11*(1), 1–6. https://doi.org/10.1038/s41467-020-17751-y

7. Hadley, A. S., & Betts, M. G. (2012). The effects of landscape fragmentation on pollination dynamics: Absence of evidence not evidence of absence. *Biological Reviews*, *87*(3), 526–544. https://doi.org/10.1111/j.1469-185X.2011.00205.x
8. Whitehorn, P. R., Goulson, D., & Brown, M. J. F. (2014). Neonicotinoid pesticide reduces bumblebee colony growth and queen production. *Science*, 343(6166), 151-153. https://doi.org/10.1126/science.1245931
9. Goulson, D., Nicholls, E., Botías, C., & Rotheray, E. L. (2015). Bee declines driven by combined Stress from parasites, pesticides, and lack of flowers. *Science*, *347*(6229), 1–16. https://doi.org/10.1126/science.1255957
10. Pandian, A. M. K., Karthikeyan, C., Rajasimman, M., & Dinesh, M. G. (2015). Synthesis of silver nanoparticle and its application. *Ecotoxicology and Environmental Safety*, *121*, 211–217. https://doi.org/10.1016/j.ecoenv.2015.03.039
11. Gao, J., Zhang, Y., Zhang, T., Yang, Y., Yuan, C., Jia, J., & Wang, Z. (2017). Responses of gonadal transcriptome and physiological analysis following exposure to 17á-ethynylestradiol in adult rare minnow Gobiocypris rarus. *Ecotoxicology and Environmental Safety*, *141*(March), 209–215. https://doi.org/10.1016/j.ecoenv.2017.03.028
12. Rundlöf, M., Andersson, G. K. S., Bommarco, R., Fries, I., Hederström, V., Herbertsson, L., Jonsson, O., Klatt, B. K., Pedersen, T. R., Yourstone, J., & Smith, H. G. (2015). Seed coating with a neonicotinoid insecticide negatively affects wild bees. *Nature*, *521*(7550), 77–80. https://doi.org/10.1038/nature14420
13. Zhonghua, M., Luo, Y. & Michailides, T. (2006). Molecular characterization of the two-component histidine kinase gene from *Monilinia fructicola*. *Pest Manag Sci*. 62. 991-998.

14. Tabashnik, B. E. (1994). Evolution of resistance to Bacillus thuringiensis. *Annual Review of Entomology. Vol. 39*, *39*, 47–79. https://doi.org/10.1146/annurev.ento.39.1.47
15. Thakur, A. K. (2021). Report on the Effect of Declined Anthropogenic Disturbance during COVID-19 Lockdown over the diversity of Butterflies. In *Quam Vita - Life Beyond* (pp. 155–160). Disha International Publishing House, Noida, UP, India.
16. Thakur, A. K. & Kumari, K. (2021). Inventory report of the butterflies (Lepidoptera: Rhopalocera) of family Nymphalidae, Pieridae and Papilionidae at the Kanke, Ranchi. *Biospectra*, *16*(2), 169–174.
17. Cameron, S. A., Lozier, J. D., Strange, J. P., Koch, J. B., Cordes, N., Solter, L. F., Griswold, T. L. and Nakamura, K. (2011). Patterns of widespread decline in North American bumblebees. *Science*. 331(6022). 151-154.
18. Aizen, M.A., Garibaldi, L.A., Cunningham, S.A., Klein, A.M. and Zacharias, J., 2016. How much does agriculture depend on pollinators? Lessons from long-term trends in crop production. *Science*. 351(6270). 972-977.
19. Kleijn, D., Winfree, R., Bartomeus, I., Carvalheiro, L. G., Henry, M., Isaacs, R., Klein, A. M., Kremen, C., M'Gonigle, L. K., Rader, R., Ricketts, T. H., Williams, N. M., Lee Adamson, N., Ascher, J. S., Báldi, A., Batáry, P., Benjamin, F., Biesmeijer, J. C., Blitzer, E. J., … Potts, S. G. (2015). Delivery of crop pollination services is an insufficient argument for wild pollinator conservation. *Nature Communications*, *6*(May). https://doi.org/10.1038/ncomms8414
20. Steffan-Dewenter, I., Potts, S. G., Packer, L., & Ghazoul, J. (2005). Pollinator diversity and crop pollination services are at risk [3] (multiple letters). *Trends in Ecology and Evolution*, *20*(12), 651–652. https://doi.org/10.1016/j.tree.2005.09.004
21. Saini, R., Saini, M. & Gill, R. (2017). Honeybee diversity, pollination and conservation in India. *Biodiversity and Environmental Sciences*. 2(3). 45-56.
22. Saini, R., Saini, M. & Gill, R. (2017). Status, challenges and future of honeybee and wild pollinators in India. *International Journal of Agriculture, Biology and Environmental Sciences*. 13(3). 1-15.